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CONSERVATION AGRICULTURE TO SUSTAIN THE PRODUCTIVITY AND SOIL HEALTH IN COTTON AND GROUNDNUT INTERCROPPING SYSTEM

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ABSTRACT

Investigations were undertaken on a fixed site of Conservation Agriculture Project at main Agricultural Research Station, University of Agricultural Sciences, Dharwad, during 2014-15 and 2015-16 on deep black clay soil to study the effect of conservation tillage and land configuration in cotton and groundnut intercropping system on growth, yield and post-harvest soil fertility status under rainfed situations. It is evident from two years of experimental findings that, conservation tillage with broad bed and furrow (BBF) and crop residue retained on the surface (CT_1) and crop residue incorporation (CT_2) significantly increased morphological traits viz., plant height, monopodia and sympodia branches, LAI and total dry matter production. Influence of these tillage systems were also noticed for yield attributes viz., total number of pods plant^{-1}, mean boll weight, seed cotton yield and stalk yield of cotton and number of pods plant^{-1}, pod weight plant^{-1}, kernel yield, haulm yield and pod yield in groundnut and productivity of a system. It was followed by conservation tillage with flat bed and crop residue retained on the surface (CT_3) and crop residue incorporation (CT_4) which also superior over conventional systems. Similarly, all the conservation tillage practices significantly improved soil organic carbon and available nutrients of soil as compared to conventional tillage without crop residues.

(Key words: Conservation tillage, cotton, groundnut, morpho-physiological traits, yield, soil fertility)

INTRODUCTION

Attaining food security for a growing population and alleviating poverty while sustaining agricultural systems under the current scenario of depleting natural resources, negative impacts of climatic variability, spiraling cost of inputs and volatile food prices are the major challenges before most of the Asian countries. The degradation of agro-ecosystem is mainly caused by (i) intensive tillage and farming induced soil organic matter decline, soil structural degradation, water and wind erosion, reduced water infiltration rates, surface sealing and crusting, soil compaction,(ii) insufficient return of organic material, and (iii) monocropping. Therefore, a paradigm shift in farming practices through eliminating unsustainable parts of conventional agriculture is crucial for future productivity gains while sustaining the natural resources. Conservation agriculture has come up as a new paradigm to achieve goal of sustained agricultural production (Suraj and Behera, 2014).

Conservation agriculture which has its roots in universal principles of providing permanent soil cover through crop residues or cover crops, minimum soil disturbance and crop rotations is now considered the principal road to sustainable agriculture. Conservation agriculture (CA), a concept evolved as a response to concerns of sustainability of agriculture globally, has steadily increased worldwide to cover about 155 M ha (Anonymous, 2014). In India, CA adoption is still in the initial phases. Over the past few years, adoption of zero tillage and CA has expanded to cover about 1.5 million hectares adopted with zero-till (ZT) wheat planting in the rice-wheat system of the Indo-Gangetic plains (Anonymous, 2014).The CA adoption also offers avenues for much needed diversification through crop intensification, relay cropping of pulses, vegetables etc.

Conservation agriculture with crop residue management practices provide many benefits to crop including erosion control, water conservation, reducing evaporation, reducing temperature fluctuations, increasing soil organic matter, improving soil structure, improving soil microbial activity, improve nutrient availability and suppressing weeds has significant effect on plant growth and crop productivity.

Intercropping of short duration crops in the inter space between two rows of a widespaced crops like cotton, which has initial slow growth, can help in better resource utilization, soil cover and stabilize crop productivity by reducing impact of weather vagaries and increase the cropping intensity (Andrews, 1972).

In India, the cotton productivity is low and is not sustainable due to many reasons. Area under groundnut is

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declining for last two decades. Hence, there is a need to sustain the productivity of cotton and also find suitable place for groundnut in a rainfed cropping system. Studies were initiated with the sustainable application of conservation agriculture practices such as minimum soil disturbance, adequate soil cover or incorporation of crop residues and broad bed and furrow practices to foster sustainable improvements in the productivity of cotton + groundnut intercropping system under rainfed conditions.

MATERIALS AND METHODS

The field experiments were conducted on a fixed experimental site of conservation agriculture project at main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka during 2014-15 and 2015-16 on neutral pH (7.4) vertic inceptisols with initial soil organic carbon (0.52%), available nitrogen (274.40 kg ha^{-1}), available phosphorus (34.26 kg ha^{-1}) and available potassium (319.20 kg ha^{-1}).The experiment was laid out in strip block design consisting of 6 tillage practices (CT_1 - Conservation tillage with BBF and crop residue retained on the surface, CT_2 - Conservation tillage with BBF and incorporation of crop residue, CT_3 - Conservation tillage with flat bed with crop residue retained on the surface, CT_4 - Conservation tillage with flat bed with incorporation of crop residue, CT_5 - Conventional tillage with crop residue incorporation and CT_6 - Conventional tillage without crop residues with three replications.

The experiment was initiated during 2013-14 and conservation tillage plots were permanently maintained with bigger plot size of 15 m width and 9 m length. In convention plots, the land was ploughed with mould board plough once, cultivated and harrowed and soil was brought to fine tilth. In conservation tillage plots, minimum tillage for crop residue incorporation with rotovater two months before sowing and no tillage plots maintained with crop residue shredding and retention on the surface during 1stweek of April, till than residues were maintained on the surface. The established weeds were killed 10 days before sowing by spraying paraquat a contact herbicide. The crop was weed free upto 30 days by pre-emergence application of pendimethalin (STOMP XTRA 38.7 CS) and later weeds were managed by post emergence application of quizalofop ethyl 5% ECat 40 DAS and also by manual weeding.

Groundnut (GPBD 4) was sown at 30 cm spacing with the help of tractor drawn seed drill by skipping one row for every two rows and in a skipped row cotton seeds of *Bt* hybrid Bindas was dibbled. After every 6 rows (180cm) a row was skipped for opening furrow (30 cm) which help to layout Broad Bed and Furrows (BBF) with 180 cm bed and 30 cm furrow immediately after sowing of the crops. All the recommended package of practices for cotton and groundnut were followed to raise the healthy crop.

During 2014, the total annual rainfall received was about 962.4 mm which was 34 per cent higher than normal. The delayed onset of monsoon during *kharif* (July first fortnight) resulted in delayed sowing of crops. During crop growth period there was uniform distribution of rainfall which helped to get good crop stand and optimum yield. During 2015, the total rainfall received was 716.2 mm which was 3 percent less than the normal rainfall. The crops were sown early in *kharif* (June second fortnight) as compared to 2014. Rainfall received during crop growth period mainly in the month of July, August and September was 73, 66 and 79 per cent lower than the normal which affected the growth and development of the crops during early stages of cotton and also groundnut resulted in lower productivity of crops.

Five cotton representative plants were sampled at harvest to record plant height (cm), monopodia and sympodia branches plant^{-1},total dry matter production (g plant^{-1}) and yield attributes viz., total number of bolls plant^{-1}, kapas weight (g plant^{-1}) and mean boll weight (g). Whereas, leaf area (dm^2 plant^{-1}) and leaf area index (LAI) of cotton were taken at 120 DAS. Similarly, five representative plants of groundnut were sampled at harvest to record plant height (cm), branches plant^{-1}, total dry matter production (g plant^{-1}) and yield attributes viz., number of pods plant^{-1} and pod weight (g plant^{-1}). In cotton, harvesting of seed cotton was done in two pickings from the net plot for computing kapas yield ha^{-1}. In groundnut, the crop was harvested when it attained maturity and the pod yield and haulm yield plot^{-1} were recorded.After harvesting of cotton, soil samples from each plot were drawn to analyze for soil organic carbon (Jackson, 1967), available nitrogen (Subbiah and Asija, 1956), available phosphorus (Muhr *et al.*, 1965) and available potassium (Muhr *et al.*, 1965).

RESULTS AND DISCUSSION

Growth, yield traits and yield of cotton

Two years pooled data showed that, seed cotton yield has significantly higher (1332, 1363 and 1305 kg ha^{-1}) with conservation tillage systems mainly conservation tillage with Broad Bed andFurrow (BBF) and crop residue retained on the surface (CT_1), conservation tillage with BBF and incorporation of crop residue (CT_2) and conservation tillage with flat bed with incorporation of crop residue (CT_4), respectively as compared to conventional tillage without crop residue (1057 kg ha^{-1}) and followed by conservation tillage with flat bed with crop residue retained on the surface (CT_3) and conventional tillage with crop residueincorporation (CT_5) (1202 and 1209 kg ha^{-1}, respectively) (Table 4). Higher seed cotton yield is governed by number of factors having direct and indirect influence. The main factors which have direct bearing on seed cotton yield are total number of bolls plant^{-1}, mean boll weight and kapas weight plant^{-1}. The growth and morphological traits like plant height, sympodial branches plant^{-1}, leaf area, leaf area index and total dry matter production plant^{-1}had positively influenced the above yield traits and further they had on seed cotton yield. The results obtained in the investigation are in close accordance with the finding of

Blaise (2011), who reported that in three years field experiment in cotton, reduced tillage with green manuring and mulching of weed biomass produced significantly higher plant height, more number of sympodial branches, morenumber of bolls m^{-2} and higher seed cotton yield over conventional tillage.

Similarly, conservation tillage with BBF and crop residue retained on the surface (CT_1), conservation tillage with BBF and incorporation of crop residue (CT_2) and conservation tillage with flatbed with incorporation of crop residue (CT_4) recorded significantly more number of total bolls plant^{-1} (41.97, 42.03 and 39.37, respectively) over conventional tillage without crop residue (CT_6, 35.90), whereas mean boll weight was significantly higher (5.17 g) in conservation tillage with BBF and incorporation of crop residue (CT_2) as compared to conventional tillage without crop residue (CT_6 ,4.28 g) and these were on par with, conservation tillage with BBF and crop residue retained on the surface (CT_1, 5.04 g), conservation tillage with flatbed with crop residue retained on the surface (CT_3, 4.87 g) and conservation tillage with flatbed with incorporation of crop residue (CT_4, 4.87 g), with respect to kapas weight, all the tillage practices (CT_1, CT_2, CT_3, CT_4 to CT_5recorded significantly higher kapas weight (134, 135, 128, 130 and 128 g plant^{-1}, respectively) except conventional tillage without crop residue (CT_6, 115 g plant^{-1}) (Table 2 and Fig. 1). Such differences with respect to yield components were reported earlier by Devkota *et al*. (2013), they showed that conservation tillage with permanent bed and wheat as a cover crop after second picking has recorded significantly higher above ground biomass, boll weight, boll density, god opened bolls and raw kapas yield of cotton. Broad bed and furrow (BBF) and cotton stalks incorporation @5.0 t ha^{-1} recorded significantly higher plant height (94.0 cm), monopodia (4.14), sympodia (12.57), LAI (1.353), TDMP (54.97 g plant^{-1}), bolls plant^{-1} (14.70), boll weight (1.60 g), cotton yield(24.23 g plant^{-1}) and seed cotton yield (1,014 kg ha^{-1}) as compared to flat bed in *desi* cotton (Hulihalli and Patil, 2005).

The growth parameters (plant height, monopodial, sympodial branches, leaf area and leaf area index and total dry matter production) differed significantly due to different conservation tillage, land configuration and crop residue management this could be due to the compound effects of many factors, namely additional nutrient, improved soil physical properties, water regimes, better water extraction, aeration and resource use rather than conventional tillage (Unger and Jones, 1998). The conservation tillage withbroad bed and furrow (BBF) and crop residue retained on the surface (CT_1) and conservation tillage with BBF and incorporation of crop residue (CT_2) produced significantly taller plant (134.90 and 134.39cm), more number of monopodials plant^{-1}(3.10 and 3.13) and sympodials (19.83 and 19.37), leaf area at 120 DAS (151.76 and 150.52 dm^2 plant^{-1}), leaf area index (2.81 and 2.79) and total dry matter production (169.13 and 167.95 g plant^{-1}),respectively as compared to conventional tillage without crop residue (CT_6)(Table 1 and Fig 1). Soil structure affects crop yield through a complex of root-based mechanisms that in turn affect the above-ground biomass (Passioura, 2002). Crop residues are direct sources of organic C and positive effects of crop residues on improvements in SOC, N and other nutrients have been noted by Yadvinder Singh *et al*. (2004).

Growth, yield traits and yield of groundnut

Two years pooled data revealed that, growth attributing characters viz., plant height, branches plant^{-1}, total dry matter production, leaf area and leaf area index at harvest were significantly higher in conservation agricultural practices over conventional practices. Conservation tillage with BBF and incorporation of crop residue (CT_2) recorded significantly higher plant height (39.82 cm), branches plant^{-1}(13.10), total dry matter production (42.96 g plant^{-1}), leaf area (10.99 dm^2 plant^{-1}) and leaf area index (3.66) overother tillage practices. However, they were on par with conservation tillage with BBF and crop residue retained on the surface (CT_1)(38.96cm, 12.63, 41.60 g plant^{-1}, 10.78 dm^2 plant^{-1} and 3.59, respectively) (Fig 2). This might be due to optimum availability of nutrients through organic crop residues and favorable soil environment through balanced soil moisture which enhanced N fixation, rate of photosynthesis and consequently led to better vegetative growth. Improved soil structure and nutrient status of the soil by crop residue and adequate moisture availability during dry spell through BBF attributed to higher growth parameters (Ajeyi, 2015).

Yield and yield attributing characters such as number of pods plant^{-1}, pod weight plant^{-1}, kernel yield, haulm yield and pod yield differed significantly as influenced conservation tillage systems and conventional tillage. Conservation tillage with BBF and crop residue retained on the surface (CT_1) and incorporation of crop residue (CT_2) recorded significantly more number of pods plant^{-1} (33.27 and 33.53, respectively) and pod weight (29.77 and 29.37 g plant^{-1}, respectively) as compared to other tillage practices. Whereas, kernel yield was higher in all the conservation tillagesystems (CT_1 to CT_4: 1205 to 1123 kg ha^{-1}) as compared to conventional tillage without crop residue (CT_6: 953 kg ha^{-1}), however they were on par with conventional tillage with crop residue incorporation (CT_5: 1075 kg ha^{-1}) (Table 3). With respect to pod yield and haulm yield, conservation tillage with BBF and incorporation of crop residue (CT_2) recorded significantly higher pod and haulm yield (1625 and 2238 kg ha^{-1},respectively), however they were on par with conservation tillage with BBF and crop residue retained on surface (CT_1) (1614 and 2166 kg ha^{-1}, respectively). The improvement in the number of pods plant^{-1} and pod dry weight plant^{-1}might be due to increased availability of moisture, nutrients in soil which might have favoured potential growth and development of the crop. Improved tillage coupled with crop residue incorporation and mulching is helpful in enhancing rain water conservation as well as it's retention and utilization for achieving higher yield.Improved cropping systems – crop rotation, intercropping etc., enhanced the soil fertility and productivity in rainfed situations (Pradhan *et al.,* 2011 and Megha *et al.*, 2008).

System productivity

The results explicitly indicate that the all the conservation tillage practices (CT_1, CT_2, CT_3 and CT_4) produced significantly higher cotton equivalent yield (2708, 2748, 246 and 2601 kg ha^{-1}, respectively) over conventional tillage system without crop residue (CT_6, 2166 kg ha^{-1}). Hence, system productivity in terms of cotton equivalent yield was higher (25, 27, 13 and 20 %) in conservation tillage systems (CT_1, CT_2, CT_3 and CT_4, respectively) than the conventional system without crop residue(CT_6). Conventional tillage with crop residue incorporation ($CT_{5,}$ 2447kg ha^{-1}) had produced 13 % higher system productivity over conventional tillage without crop residue (CT_6, 2166 kg ha^{-1}) (Table 4).Conservation tillage to both cotton and maize on flat bed planting and furrow irrigated raised bed recorded significantly higher cotton equivalent yield (46 and 48 q ha^{-1}, respectively) (Puvila and Siddeswaran, 2014).

Soil organic carbon (SOC)

Improvement of soil organic matter (SOM) is a desirable aim as it is associated with better plant nutrition, crop performance and soil physical properties (greater aggregate stability, reduced bulk density, improved water holding capacity, enhanced porosity). SOC of surface soil is considered as a primary indicator of soil quality. Combined implementation of conservation tillage, land configuration with crop residues management increased the soil organic carbon in the topsoil. Conservation tillage with BBF and crop residue retained on the surface ($CT_{1,}$ 0.61 %), conservation tillage with BBF and incorporation of crop residue (CT_2, 0.62 %), conservation tillage with flatbed with crop residue retained on the surface (CT_3, 0.58 %), conservation tillage with flatbed with incorporation of crop residue (CT_4, 0.60 %) and conventional tillage with incorporation of crop residue (CT_5, 0.54%) increased SOC about 26, 29, 20, 24 and 11 % respectively over conventional tillage without crop residue (CT_6, 0.48 %) (Fig 3). Crop residues incorporated in to the soil decompose very fast as compared to residue present in surface, generally in no till, reduced till and strip till system where soil destruction is reduced and residues are present in surface or near surface resulted in higher SOC than the conventional tillage (Singh and Ladha, 2004).

Available nutrient status

Nature and frequency of tillage, residue management practices had significant effects on nutrient content, its distribution and transformations. The nutrient distribution, availability on soil in no till is similar to the soil organic carbon (SOC) content and distribution as it increased the nutrient availability on and near soil surface as compared to conventional tillage. Two years of experimental results showed that conservation tillage with BBF and incorporation of crop residue (CT_2) recorded significantly higher available nitrogen (238 kg ha^{-1}) as compared to conventional tillage without crop residue (CT_6, 212.80 kg ha^{-1}), however, it was on par with conservation tillage with BBF and crop residue retained on the surface (CT_1, 212.80 kg ha^{-1}). At 10 cm depth, 21% higher total nitrogen was recorded under no till and permanent raised beds compared to conventional till. This is because of reduced losses of nitrogen by leaching, surface run off, erosion and build-up of a larger pool of mineralized organic N (Thomas *et al.*, 2007). Whereas, available phosphorus was higher in conservation tillage with BBF and incorporation of crop residue (CT_2, 31.39 kg ha^{-1}) followed by conservation tillage with BBF and crop residue retained on the surface (CT_1, 31.13 kg ha^{-1}), this might be due to higher proportion of residues in the surface under no/minimum till systems had increased microbial biomass that lead to higher P content (Franzluebbers *et al.*, 1994). With respect to available potassium, conservation tillage with BBF and crop residue retained on the surface (CT_1) conservation tillage with BBF and incorporation of crop residue (CT_2) and conservation tillage with flatbed with incorporation of crop residue (CT_4) recorded higher available potassium (275.20, 276.00 and 271.60 kg ha^{-1}, respectively) over conventional tillage without crop residue (CT_6, 250.90 kg ha^{-1}) followed by conservation tillage with flatbed with crop residue retained on the surface (CT_3, 265.60 kg ha^{-1}) and conventional tillage with incorporation of crop residue (CT_5, 266.80 kg ha^{-1}) (Fig 4). It could be due to the inversion of top soil during ploughing which shifts less fertile subsoil to the surface in addition to possible leaching of nutrients (Busari and Salako, 2013) and also crop residue are the good source for improving particularly acidic and poor fertile soil in terms of raising soil pH, increasing soil organic matter and is also important to incorporate legume and cereals residues before 45 to 60 days of planting (Sarma and Chakravarty, 2013).

Conservation tillage and BBF with both crop residue retention on the surface and incorporation treatments with intensive cropping systems of cotton + groundnut found more productive and profitable. Conservation tillage with legume crop intensification eliminates unsustainable part of conventional agricultural system and are crucial for sustaining productivity and conservation of natural resources under rainfed farming.

Table 1. Growthparameters of cotton as influenced by different conservation tillage practices in cotton + groundnut intercropping system

Tillage systems		Plant height (cm)			Monopodia $plant^{-1}$			Sympodia $plant^{-1}$			Leaf area index at 120 DAS		
		2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
CT_1 -Conservation tillage with BBF and crop residue retained on the surface.		144.20a	125.61a	134.90a	3.13a	3.07ab	3.10a	24.40a	15.27ab	19.83a	3.06a	2.56a	2.81a
CT_2 -Conservation tillage with BBF and incorporation of crop residue.		143.10a	125.67a	134.39a	3.13a	3.13a	3.13a	23.00ab	15.73a	19.37a	3.03a	2.55a	2.79a
CT_3-Conservation tillage with flat bed with crop residue retained on the surface.		138.69b	114.54b	126.62b	3.13a	2.80c	2.97ab	21.47bc	14.53c	18.00c	2.77b	2.22b	2.50b
CT_4-Conservation tillage with flat bed with incorporation of crop residue.		138.28b	118.02b	128.15b	3.00a	2.87bc	2.93ab	21.67bc	14.87bc	18.27bc	2.73b	2.27b	2.50b
CT_5-Conventional tillage with crop residue incorporation.		137.66b	118.97b	128.32b	3.00a	2.87bc	2.93ab	20.07c	15.07bc	17.57cd	2.71b	2.30ab	2.50b
CT_6-Conventional tillage (no crop residue).		136.41b	116.76b	126.58b	3.00a	2.67c	2.83b	19.53c	13.40d`	16.47d	2.62b	2.13b	2.38b
SEm ±		**1.31**	**1.79**	**1.34**	**0.10**	**0.0**	**0.08**	**0.64**	**0.18**	**0.39**	**0.06**	**0.82**	**0.06**
F test	**5%**	*	*	*	**NS**	*	*	*	*	*	*	*	*
	1%	**	**	**	**NS**	**NS**	**NS**	**	**	**	**	**NS**	**

NS: Non significant, *: Significant at 5%, **: Significant at 1%

Table 2. Yieldparameters of cotton as influenced by different conservation tillage practices in cotton + groundnut intercropping system

Tillage systems		Total number of bolls plant^{-1}			Mean boll weight (g)			Stalk yield (kg ha^{-1})		
		2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
CT_1 -Conservation tillage with BBF and crop residue retained on the surface.		46.73a	37.20ab	41.97a	5.55a	4.54a-c	5.04ab	2868a	2390a	2629a
CT_2 -Conservation tillage with BBF and incorporation of crop residue.		44.93ab	39.13a	42.03a	5.47a	4.87a	5.17a	2816ab	2418a	2617a
CT_3-Conservation tillage with flat bed with crop residue retained on the surface.		43.00ab	34.33bc	38.67ab	5.42a	4.32bc	4.87ab	2643a-c	2199ab	2421a-c
CT_4-Conservation tillage with flat bed with incorporation of crop residue.		43.27ab	35.47a-c	39.37ab	5.15ab	4.60ab	4.87ab	2744ab	2234ab	2489ab
CT_5-Conventional tillage with crop residue incorporation.		41.87ab	35.93a-c	38.90ab	4.88ab	4.48a-c	4.68bc	2543bc	2098b	2320bc
CT_6-Conventional tillage (no crop residue).		39.67b	32.13c	35.90b	4.44b	4.12c	4.28c	2417c	1973b	2195c
SEm ±		**1.57**	**1.30**	**1.31**	**0.22**	**0.14**	**1.14**	**80.77**	**85.12**	**81.74**
F test	**5%**	**NS**	*	**NS**	*	*	*	*	*	*
	1%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

NS: Non significant, *: Significant at 5%, **: Significant at 1%

Table 3. Yield and yield parameters of groundnut as influenced by different conservation tillage practices in cotton + groundnut intercropping system

Tillage systems (T)	Number of pods $plant^{-1}$			Pod weight (g $plant^{-1}$)			Kernel yield (kg ha^{-1})			Haulm yield (kg ha^{-1})		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
CT_1 -Conservation tillage with BBF and crop residue retained on the surface.	35.87a	30.67ab	33.27a	32.07a	27.47ab	29.77a	1414a	996ab	1205a	2297a	2035ab	2166a
CT_2 -Conservation tillage with BBF and incorporation of crop residue.	35.13a	31.93a	33.53a	30.73ab	28.00a	29.37a	1395a	1010a	1203a	2354a	2122a	2238a
CT_3-Conservation tillage with flat bed with crop residue retained on the surface.	32.87ab	26.80ab	29.83bc	28.40bc	23.20c	25.80b	1255ab	923b	1089a	2168ab	1992a-c	2080bc
CT_4-Conservation tillage with flat bed with incorporation of crop residue.	32.33ab	27.20ab	29.77bc	28.47bc	23.87bc	26.17b	1313ab	934b	1123a	2246a	1999a-c	2123b
CT_5-Conventional tillage with crop residue incorporation.	30.47bc	26.27ab	28.37bc	27.07c	23.27c	25.17b	1225ab	925b	1075ab	2129ab	1906bc	2017c
CT_6-Conventional tillage (no crop residue).	28.00c	25.87b	26.93c	25.53c	21.40c	23.47b	1075b	830c	953b	1975b	1825c	1900d
SEm ±	**1.20**	**1.21**	**0.85**	**1.08**	**1.15**	**0.83**	**71.30**	**23.02**	**41.33**	**74.17**	**56.23**	**30.23**
F test 5%	*	*	*	*	*	*	*	*	*	*	*	*
F test 1%	**	**NS**	**	**NS**	**NS**	**	**NS**	**	**NS**	**NS**	**NS**	**

NS: Non significant, *: Significant at 5%, **: Significant at 1%

Table 4. Seed cotton yield, groundnut pod yield and cotton equivalent yield as influenced by different conservation tillage practices in cotton + groundnut intercropping system

Tillage systems (T)	Seed cotton yield (kg ha^{-1})			Groundnut pod yield (kg ha^{-1})			Cotton equivalent yield (kg ha^{-1})		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
CT_1 -Conservation tillage with BBF and crop residue retained on the surface.	1454a	1209a	1332a	1863a	1365ab	1614ab	3084ab	2332a	2708a
CT_2 -Conservation tillage with BBF and incorporation of crop residue.	1502a	1223a	1363a	1854a	1396a	1625a	3124a	2371a	2748a
CT_3-Conservation tillage with flat bed with crop residue retained on the surface.	1328ab	1075ab	1202b	1668ab	1275b	1471bc	2789bc	2124b	2456b
CT_4-Conservation tillage with flat bed with incorporation of crop residue.	1430a	1180a	1305a	1746a	1293b	1520a-c	2959ab	2243ab	2601ab
CT_5-Conventional tillage with crop residue incorporation.	1229bc	1190a	1209b	1628ab	1279b	1454c	2653cd	2241ab	2447b
CT_6-Conventional tillage (no crop residue).	1157c	957b	1057c	1441b	1162c	1302d	2418d	1913c	2166c
SEm ±	**51.82**	**45.72**	**26.76**	**82.30**	**26.89**	**43.61**	**90.33**	**45.82**	**55.87**
F test 5%	*	*	*	*	*	*	*	*	*
F test 1%	**	**NS**	**	**NS**	**	**	**	**	**

NS: Non significant, *: Significant at 5%, **: Significant at 1%

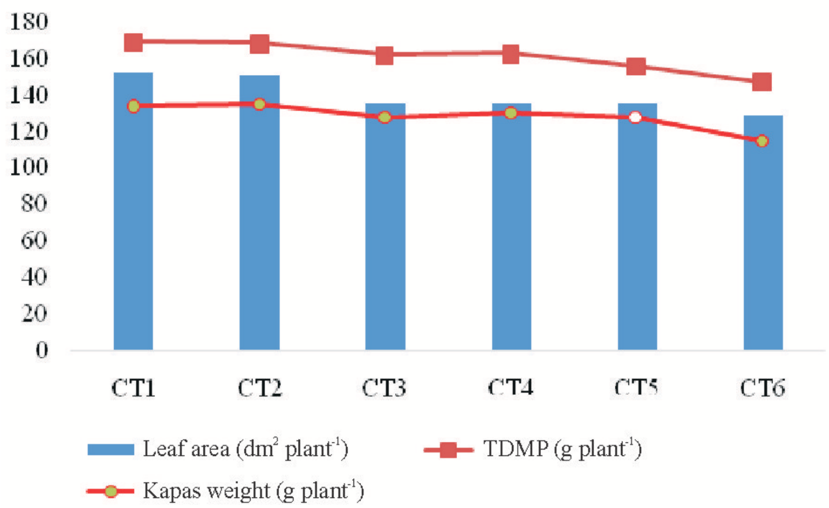

Fig. 1.Cotton leaf area at 120 DAS, TDMP and kapas weight as influenced by different conservation tillage practices

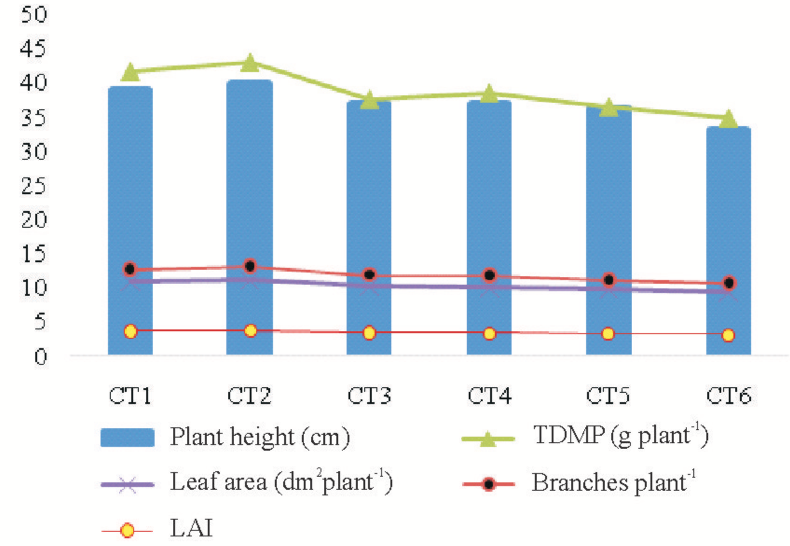

Fig. 2. Growth parameters of groundnutas influenced by different conservation tillage practices

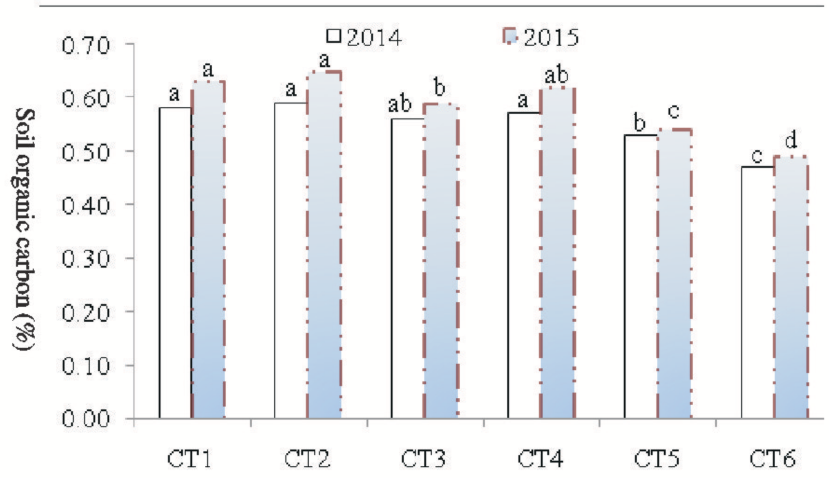

Fig. 3. Soil organic carbon as influenced by different conservation tillage practices

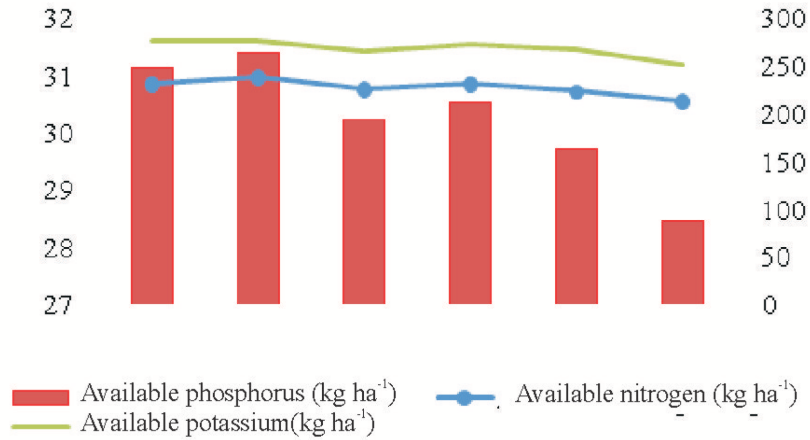

Fig. 4. Soil nutrient status as influenced by different conservation tillage practices

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